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Southern Pine Beetle Survival In Trees Felled By the Cut and Top-Cut and Leave Method

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SUMMARY

When the cut & top-cut & leave method was used for control of the southern pine beetle in Central Louisiana, trees were felled into the open or into shade in September, June, July, December, and January. Survival was greatest in September, moderate in July, and relatively low in June, December, and January. The cut and top treatment resulted in lower beetle survival in both the cold and hot seasons. Survival was 17 percent for cut and top, 32 percent for cut and leave, and 35 percent for controls. Survival was apparently related to high inner-bark moisture levels, which were 61 percent for cut and top trees and 51 percent for cut and leave. Total brood survival in trees felled into the open was not significantly different from that in trees felled into shade because many insects on the underside of trees felled into the open survived. Turning the logs so that both surfaces can be exposed to direct sunlight would probably give improved control. Even though these tests indicate that cutting and topping trees into an opening may decrease brood survival, the total population was not eliminated. It is not yet known if enough beetles survive to maintain the population and to spread to other trees. But spread is undoubtedly disrupted by treatment because the beetles must emerge from felled trees and seek new hosts outside the treated area.

Additional keywords: *Dendroctonus frontalis*, *Pinus taeda*, pest control, inner-bark moisture and temperature.

Southern Pine Beetle Survival In Trees Felled By the Cut and Top-Cut and Leave Method

No fully effective, practical, and economical pest management system has been developed for controlling the southern pine beetle (*Dendroctonus frontalis* Zimmerman). Control measures have typically consisted of either cutting infested trees and spraying with pesticide (BHC or lindane in No. 2 fuel oil), salvage removal, or piling and burning of infested material. Many infestations are too small and scattered for practical salvage removal, and concern has been voiced about environmental contamination by chemicals or burning. Consequently, an alternative approach to beetle control, the cut & top-cut & leave method, is being tried in Texas and other states by both public and private timber growers (Anonymous 1975, Ollieu 1969, Williamson 1970). With this method, all infested trees are felled as are all trees within a 40- to 60-foot-wide buffer strip around the active portion of each infestation. Beetles are thought to thrive in moderately dry, cool environments; thus, if felling is done during the hot season (May-October), the insects are theoretically killed by extremely dry inner-bark conditions and high temperatures that result from exposing the felled tree to direct sunlight. During this season, the trees are simply cut and left without topping them so that transpiration of moisture from the trunk to the needles will enhance the very dry, hot conditions in the inner bark. In trees felled during the cool season (November-April) the insects supposedly die because of high inner-bark moisture content. Trees felled during the cool season are therefore topped after cutting to maintain high moisture levels by preventing transpiration. The present paper compares bark beetle survival in standing trees, trees that were cut-and-left, and those that were cut-and-topped.

METHODS

Southern pine beetle infestations of loblolly pines (*Pinus taeda* L.) were studied in the Kisatchie National Forest in 1974-75. Because of an insufficient number of winter infestations, we were unable to determine seasonal differences (summer vs. winter) in treatment effectiveness. Instead we compared data obtained for five plots, representing active infestations selected in June, July, September, and December, 1974, and January 1975. In each plot (month) two trees were left standing (control), and eight were felled. The felled trees were divided into two groups of four trees each. Trees of one group were felled under partial shade or overstory and trees in the other group were felled in an opening to allow maximum exposure to sunlight. To compare cutting treatments on various stages of brood development, each group of felled trees contained two trees that were cut and topped and two trees that were cut and left; one tree in each treatment pair was infested with early brood (egg, young larvae) in the inner bark and one tree with late brood (older larvae, pupae) in the outer bark.

Beetle populations were sampled by removing circular bark disks with a 3/8-inch power drill equipped with a 4½-inch hole saw. Samples were taken from both the exposed and under surfaces of felled trees at three locations along the stems: 6 feet above the lower limit of the infested zone, at the mid-point of infestation, and 6 feet below the upper limit of the infested zone. To determine when brood mortality occurred, bark samples were taken at various stages of insect development. For trees containing mid- to late brood, bark disks were taken immediately after cutting and again just before brood emergence. For trees containing early brood, disks were taken at cutting, at the intermediate stage of development, and just before emergence. Early-stage samples were hand-

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dissected to insure a reliable brood count. Beetle counts from all mid- and late-stage samples were made from radiographs of the bark disks taken with a Faxitron x-ray unit. Duplicate series of late-stage sample disks were taken from all trees for rearing in an insectary and comparison with late-stage x-rays. A survival percentage was determined for each of the three locations on the trees by comparing the number of beetles at final emergence to the maximum number (all stages) found by hand dissection or in x-rays of early samples.

Moisture levels of both inner and outer bark were measured when the trees were felled; during the hot months measurements were repeated at weekly intervals until the broods emerged. Measurements were less frequent during the winter because of slower brood development. Samples were taken with an arch punch near the spot where bark disks were removed for beetle counts and were separated into inner and outer bark at the cork cambium.

Bark temperatures were measured by means of thermocouples and a thermocouple thermometer with a built-in reference junction. For early broods, thermocouples were inserted into inner bark and for late stages into the outer bark. Bark and air temperatures were measured immediately adjacent to areas sampled for beetle counts (two samples at three heights on the infested trunk). Because we wished to compare beetle mortality under shaded versus sunny conditions, we measured bark temperatures only on days when the greatest contrasts occurred between shaded and open conditions--on clear hot days in summer and on clear, and unusually warm or cold days in winter.

Data for brood survival were subjected to analysis of variance after arc sine transformations.

RESULTS AND DISCUSSION

Differences in survival rates for individual sampling dates were highly significant ($P > 0.01$). Survival was greatest in September, moderate in July, and relatively low in June, December, and January (fig. 1). In September, bark temperatures were moderate compared to June and July

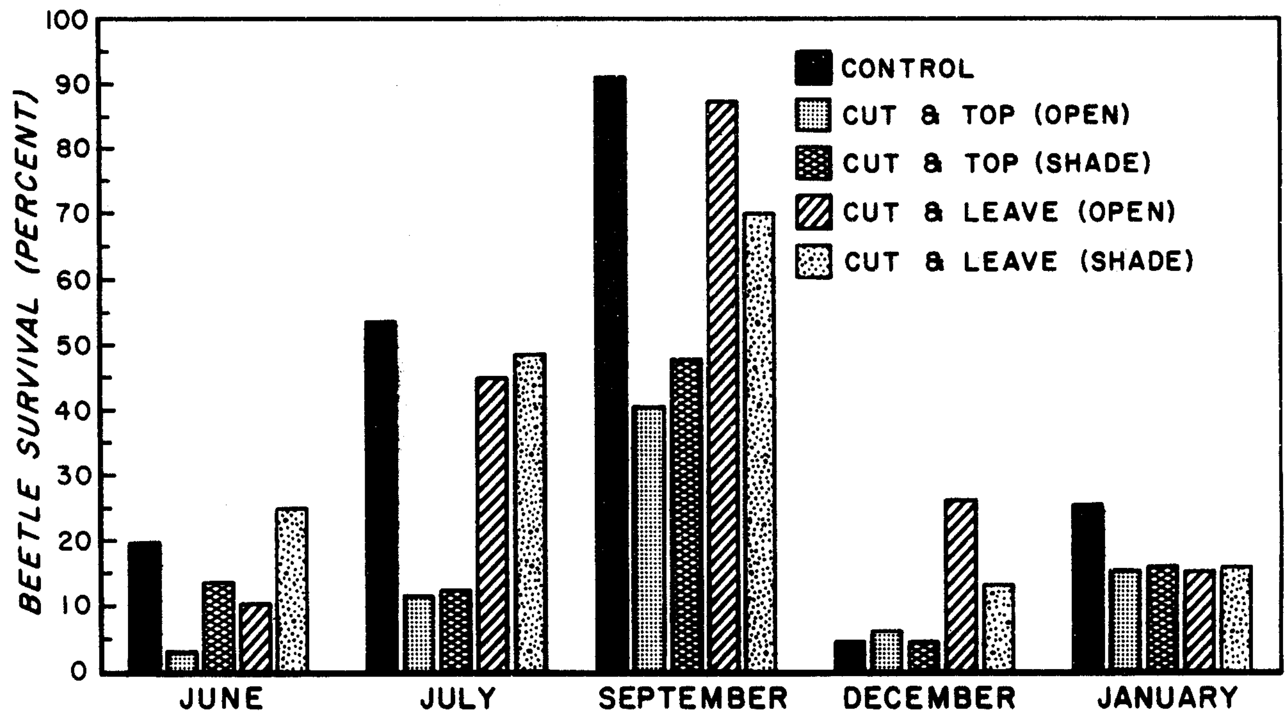

Figure 1.—Survival (percent) of southern pine beetles in Control, Cut & Top, and Cut & Leave Trees felled into the open and into shade.

temperatures, and inner-bark moisture was lower than in December and January (table 1).

Survival was much lower (P=0.05) for cut-and-top trees (17 percent) than for either cut-and-leave (32 percent) or standing trees (35 percent), which did not differ significantly from each other. The survival differences between the two felling treatments appeared related to inner-bark moisture levels (table 2). The average moisture level (wet weight basis) during the time the broods were developing was 61 percent for cut-and-top trees and 51 percent for cut-and-leave trees. In the few cases where survival for cut-and-top trees was as good as that of cut-and-leave trees, moisture levels of both treatments were comparable.

The cut-and-top treatment resulted in lower beetle survival in both the cold and hot season. The extremely hot dry inner-bark conditions that should presumably cause high summer brood mortality in cut-and-leave trees may not occur because of frequent overcast or rainy days. Thus, trees should be topped after felling regardless of season. Beal (1933) found that when felled logs were exposed to direct sunlight, high brood mortality occurred because of high inner-bark temperatures. He reported

Table 1.—Beetle survival, inner-bark temperature and bark moisture levels after tree felling treatments over several months.

Month of felling	Standing Tree (control)		Felled into Shade				Felled into Sunlight			
			Upper-Surface	Under-Surface	Average		Upper-Surface	Under-Surface	Average	
JUNE										
Survival (percent)	19.6		15.1	24.7	19.9		3.8	9.2	6.5	
Inner-bark temperature (°c)	29.1	(32.3)[a]	33.6	29.2	31.4	(32.6)	54.9	34.1	49.5	(38.0)
Moisture content (percent)[b]	43.2		52.1	52.1	52.1		31.7	49.2	40.4	
JULY										
Survival (percent)	53.5		30.7	28.6	30.7		3.0	61.9	31.5	
Inner-bark temperature (°c)	33.3	(32.8)	34.2	29.7	32.0	(33.0)	51.1	36.4	43.8	(37.0)
Moisture content (percent)	44.0		60.5	54.0	57.2		48.3	53.8	51.0	
SEPTEMBER										
Survival (percent)	91.0		40.3	71.3	57.9		30.5	91.1	58.9	
Inner-bark temperature (°c)	23.3	(24.2)	21.2	19.0	20.1	(22.9)	31.7	22.8	27.2	(27.5)
Moisture content (percent)	48.4		54.0	55.0	54.5		56.2	59.0	57.6	
DECEMBER										
Survival (percent)	4.2		6.5	10.2	8.3		18.0	16.4	17.2	
Inner-bark temperature (°c)	0.1	(3.1)	-1.6	-0.7	-1.2	(0.7)	-2.4	-1.4	-1.9	(-0.5)
Moisture content (percent)	64.6		59.0	54.9	57.0		54.4	61.3	57.8	
JANUARY										
Survival (percent)	25.7		12.8	18.4	17.7		12.9	16.9	15.3	
Inner-bark temperature (°c)	7.6	(7.5)	8.8	5.5	7.2	(8.1)	14.4	8.2	11.3	(8.5)
Moisture content (percent)	63.6		73.2	73.0	73.1		67.7	69.2	68.4	

[a] Air temperature shown in parentheses.

[b] Wet weight.

Table 2.—Inner-bark moisture content and beetle survival in control (C), cut and top (C&T), and cut and leave (C&L) trees.

DATE	Moisture Content (wet weight)			Survival		
	C	C&T	C&L	C	C&T	C&L
	Percent					
JUNE						
Upper surface	[1]43.2	46.8	37.0	[1]19.6	6.4	11.4
Lower surface	--	55.6	45.7	--	7.1	26.1
JULY						
Upper surface	44.0	60.1	48.7	53.5	7.0	29.3
Lower surface	--	58.7	49.1	--	15.9	63.9
SEPTEMBER						
Upper surface	48.4	59.6	50.6	91.0	20.0	59.7
Lower surface	--	59.0	55.1	--	71.2	90.8
DECEMBER						
Upper surface	64.6	62.3	51.0	4.2	3.9	19.1
Lower surface	--	65.3	50.9	--	6.1	19.6
JANUARY						
Upper surface	63.6	69.1	68.4	25.7	12.5	13.3
Lower surface	--	70.2	73.2	--	18.2	17.2

[1] Values for controls (C) are averages taken from two aspects on standing trees.

that almost all of the brood and adults were dead after 1- to 2-hours of exposure to direct sunlight at about 14°C. In the present study, survival was very low for insects collected from the exposed side of felled trees, an apparent result of high temperatures and consequently lower moisture levels (table 1). On sunny days, high bark temperatures prevailed for about 3 hours. Even so, total brood survival in trees felled into the open was not significantly different from that in trees felled into shade because of the relatively high survival of insects on the under side of trees felled into the open. Turning the logs to expose all surfaces to sunlight would probably give better control (Beal 1933). Felling trees away from the stand into an opening would also place infested material away from live trees.

Total beetle survival in felled trees was not significantly affected by stage of insect development at time of felling. However, for trees felled in June and July, most of the mortality (74 percent) occurred before the larvae reached the mid- to late-larval stage; whereas, in December and January almost all mortality occurred between late-larval stage and emergence. In September, greatest mortality in trees cut into an opening occurred by the late-larval stage (76 percent), but for trees felled into a stand, only 15 percent of the total mortality had occurred by that stage. Although bark averaged 0.2 inch thicker at the basal end of the infested trunk than at the upper end, we could detect no interaction between bark thickness and beetle survival--even for felled trees exposed to full sunlight.

The cut-and-top technique should logically prevent spot growth or proliferation by decreasing survival of developing broods in felled trees or by disrupting the normal spread of infestation into newly attacked, nearby trees by surviving beetles. The present work indicates that cutting and topping into an opening may decrease brood survival, especially if the entire log is exposed to direct sunlight. However, the total population is not eliminated, as was also demonstrated by Ollieu (1969). It is not yet known if enough beetles survive to pose a serious threat to surrounding forests. However, spread is undoubtedly disrupted since the beetles are emerging from felled trees, and there are no attractive trees nearby for them to attack.

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